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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
		5,809,171	9/1998	Auty et al.			

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FOREIGN PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc.)

		M25 Video Survey, Department of Transport, February, 1991
		Letter to Dr. A. Rawlins, Science and Engineering Research Council, January 15, 1992
		Letter to Mr. R. Holmes, Department of Transport, February 21, 1992
		Agenda for Department of Transport meeting, April 2, 1992
		Travers Morgan internal memo, April 3, 1992
		Letter to Mr. G. Hill, Travers Morgan, January 20, 1993
		Letter to Mr. J. Dinner, ACPO, September 7, 1993

EXAMINER	DATE CONSIDERED

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#1

THE DEPARTMENT OF TRANSPORT

Eastern Construction Programme Division

M25 Video Survey Junctions 15 – 16

Final Report February 1991

TRAVERS MORGAN

TABLE OF CONTENTS

1. INTRODUCTION

1.01 This report describes the traffic survey undertaken on 30 October 1990 on the M25 between junctions 16 (M40) and 15 (M4).

1.02 The survey was undertaken using video cameras to record vehicle registration numberplates in order to identify entry and exit points for each vehicle.

1.03 The traditional approach to numberplate surveys has involved one of the following techniques:

- Manual recording using data loggers, paper/pencil or tape recordings. This often involves recording partial numberplate details only because of traffic speed and density.
- Video recording followed by manual transcription, which can be very slow.

1.04 For this survey, a new technique was used to transcribe numberplates from the video film recordings. This involved computer image processing to digitise numberplates directly into computer data files without manual intervention.

1.05 The survey had two objectives. The first was to provide data for the current study into widening this section of the M25. The second objective was to demonstrate that the technique of computer image processing produces accurate and reliable results under a variety of traffic and lighting conditions.

1.06 If successful, it was considered that the technique had numerous applications, particularly on roads and motorways with high speeds and traffic densities.

2. FIELDWORK

2.01 The traffic survey covered the area shown in Figure 1. Traffic was filmed in a southbound direction on Tuesday 30 October 1990. The period 8.05am to 11.13am was covered continuously using thirteen video cameras, one for each lane of traffic.

2.02 A three hour time period was required to cover as much of the morning peak as possible. The start time was constrained to one hour after sunrise (6.50am), by when it was expected that lighting conditions would be satisfactory.

2.03 Six cameras were required to survey the southbound traffic entering the section at the M40 junction and seven cameras were required to survey the southbound traffic leaving the section at the M4 junction. Northbound traffic and non-M25 traffic through both junctions was not surveyed.

2.04 All but one camera at the M40 junction were mounted on the hard shoulder of the M40 overbridge viewing down onto the traffic below. The remaining camera and all the cameras at the M4 junction were mounted on overhead sign gantries. No cameras were therefore mounted on the roadside at the same level as the traffic being filmed.

2.05 Each camera was monitored throughout the survey and minor adjustments made to reflect lighting and traffic conditions. This required skilled camera operatives to be responsible for individual cameras or groups of cameras on, say, the same gantry. One operative was responsible for a maximum of three cameras.

2.06 The weather was bright with occasional cloud cover. This required changes to the optical settings of the cameras. The breezy conditions did not affect the performance of the system although one camera was blown over, probably because of the effect of a passing lorry, and ceased recording for a few minutes. In subsequent video surveys, cameras were weighed down with ballast bags on each leg of their tripod.

2.07 Traffic conditions were considered by the Department of Transport to be normal. There were no reported incidents. Vehicles were generally free flowing except on the M25 at the M40 junction. Here, southbound traffic merging from the slip road into the main carriageway caused stop-start conditions throughout the survey period but particularly in the first two hours. This required the video cameras to be mounted at a steeper angle to the carriageway, with consequent adjustments to field of view settings.

2.08 Generally speaking this did not lead to any loss of data except where, say, cars were following very closely behind larger vehicles.

2.09 Camera operatives were in contact with each other throughout the survey using portable radios. In this way, maximum control was exercised over the operation of the survey.

2.10 Temporary power supplies were provided for gantry mounted cameras via the permanent power supply box. This obviated the need to power the cameras by batteries which have a normal life of between 1 and 2 hours. The

replacement of camera batteries during filming would cause the loss of several minutes of film recordings. For the overbridge mounted cameras, a continuous power supply was provided by specially prepared battery accumulators, which lasted for the duration of the survey without interruption.

2.11 All cameras were set up between 5.30am and 8.00am on the morning of the survey. This was slightly longer than anticipated, primarily because this was a trial, requiring additional checks. There were no reliability problems with any of the cameras, although one spare video camera was available at each junction. The portable radios did begin to lose power at the end of the survey, although contact was maintained by relaying messages between operatives.

2.12 The survey was commenced by the passage of a marker vehicle under the camera mounted on the gantry over the slip road from the M40 (Westbound) to the M25 (Southbound). This occurred at approximately 8.05am at which time a message was relayed to commence filming with the other five cameras at the M40 junction. Cameras at the M4 junction commenced filming when the marker vehicle passed under the gantry where the slip road diverges from the main M25 carriageway. All seven cameras started filming by 8.14am.

2.13 The survey ended a similar way, with the marker vehicle leaving the M40 junction at 11.06am and passing the M4 junction at 11.13am. In practice, most cameras filmed traffic for a few minutes more than 3 hours.

2.14 There were no significant problems experienced during the survey either through weather or traffic conditions. The operatives recorded any relevant technical data onto

the video tape soundtrack, which was also used to record the time at frequent intervals.

2.15 It must be stated that the technique was not exposed to severe weather conditions for this trial, although there is no reason to suppose that this would have caused undue problems. All cameras had covers available for use in the event of rain.

2.16 Safety procedures were strictly adhered to. All operatives wore reflective jackets providing the highest level of conspicuity specified by BS 6629: 1985. All vehicles had a roof mounted flashing beacon. Vehicles were parked on the hard shoulder and coned off. All operatives were in possession of a valid motorway pass.

2.17 Although motorway police were aware of the surveys, there was no contact made during the work. There was no feedback from motorists although some drivers were seen to be waving at either the cameras or the operatives. This indicates a possible need to ensure cameras and operatives are concealed as far as possible so as not to distract motorists.

2.18 It is considered that the practical arrangements surrounding the survey were totally satisfactory and would need only minor amendment for subsequent work.

2.19 The nature of the trial was such that not all circumstances which might effect this technique occurred. In particular, severe weather and the need for cameras mounted alongside the carriageway would need to be examined in a future survey. However, the overriding view is that the fieldwork aspects of the trial were a success.

3. DATA PROCESSING

3.01 Data processing was subdivided into three main stages as follows:

- image processing of video tapes to transcribe registration numberplates
- manual vehicle count from video tapes
- matching of numberplates and grossing up.

3.02 For the purposes of control of data, all video tapes were clearly marked to identify their contents. This is essential because it would be virtually impossible to do this based on recorded images alone once the video films had been removed from their cameras.

3.03 Relevant data for each video camera is given in Table 1. Camera number and location should be interpreted using Figure 1. The start time and finish time are self explanatory. Cameras at the M40 junction started 3 to 9 minutes before and finished 1 to 11 minutes before cameras at the M4 junction. The variation is due to the time taken between the marker vehicle being first observed, any message relayed, and then operatives reaching all cameras at a particular location.

3.04 The filenames referred in Table 1 are of the computer files containing all the registration numberplates successfully processed and their time of observation. The format of this computer file is as shown in Appendix A.

3.05 The number of Plate Triggers is the number of times the image processing identified what was considered to be a numberplate. This includes numberplates which can be successfully read, those which cannot (because they are dirty, broken or do not conform to a recognised syntax-see Appendix B) together with other images such as lettering on the exterior of vehicles particularly commercial vehicles.

3.06 The number of plates which were successfully read is also recorded. Checks were made on the accuracy of the numberplate recognition system. These indicated that certain characters were sometimes misread. Most typical misreads were "O" and "D", "5" and "9", "6" and "8", "E" and "F", "F" and "P", "5" and "6", "V" and "U".

3.07 A manual classified vehicle count was taken from each video film. The purpose of this was threefold:

- to establish recognition rates
- to establish an approximate relationship between Plate Triggers and traffic flow
- to establish matching rates.

The first two relationships are shown in Table 2. The recognition rate (No of plates/Total Flow) was in the range 84%-97% for all cameras, which was considered very satisfactory. Table 2 revealed no firm relationship between the rate of Plate Triggers and lane type or vehicle composition. However, the three main carriageway lanes at Junction 16 (M40) have higher Plate Trigger rates than the corresponding lanes at Junction 15 (M4). This is most likely attributable to the fact that stop-start conditions prevailed at Junction 16, whilst free-flow conditions prevailed at Junction 15.

3.08 The manual vehicle count was validated against hourly automatic traffic count (ATC) data for the day of the survey at both junctions (see Appendix C). There was a very close match, with most manual counts being within 5% of the corresponding automatic count, and all being within 10%.

3.09 It should be noted that the ATC site on the M25 southbound at Junction 16 is some distance to the south of the corresponding camera positions. Also, an ATC will detect the passing of a vehicle almost irrespective of where that vehicle is in relation the lane markings. For the manual count, the field of view of the camera is much narrower and some vehicles may be missed. The comparison in Appendix C supports this.

3.10 Numberplates recorded at the M40 junction were then matched to those at the M4 junction using in-house computer software called REGNUMS. Numberplates are entered into REGNUMS by camera position as either entering and leaving. The matching procedure has a logic check to ensure that the time of observation of a leaving plate is after its corresponding entry time of observation. Since there was a staggered start time to allow for the travel time between junctions, it is considered that most vehicles entering were also seen leaving.

3.11 REGNUMS produced three computer files as follows:

- file of matched numberplates
- file of unmatched numberplates entering at the M40 junction
- file of unmatched numberplates leaving at the M4 junction.

3.12 The unfactored matched movements between entry and exit points are shown in Table 3. The overall matching rate for full numberplates (irrespective of length) was 45%. The matching rates for individual rows and columns in Table 3 are evenly spread between 41% and 51%. This, combined with the even spread of recognition rates, suggests that there is no particular bias in the individual movements indicated by Table 3.

3.13 Given the evidence which suggests that certain characters may be misread, this is considered to be an excellent matching rate. Nonetheless it was considered to be of great value that partial numberplates be matched. Incorporating numberplates matched on 5 and 6 characters out of 7 character numberplates and 5 characters out of 6 character numberplates results in the matching rates shown in Table 4 and the pattern of unfactored movements between entry and exit points shown in Table 5 (partial numberplates) and Table 6 (full and partial numberplates).

3.14 It can be seen from Table 4 that the inclusion of matched partial numberplates increases the matching rate from 45% to 67%. Even with this reduced level of accuracy, the results are still more reliable than would be obtained from convential partial numberplate surveys using a registration year letter and three letters/numbers.

3.15 It is clear from Table 5 that there was an even distribution of partial numberplate matching for all movements.

3.16 Using the above data, grossed up vehicle movements were calculated and the results are given in Table 7. The method used for this grossing up process is described in Appendix D.

3.17 The process was further refined by producing grossed up movements between entry and exit points for a peak hour. In this instance, this was for the one hour period from 8.15am to 9.14am, as observed at entry point. No account was taken of actual leaving time since a staggered start was used. These movements are shown in Table 8 and, graphically, in Figure 2. The peak hour matching rate was 74%, compared to 67% for the three hour period.

3.18 Comparing the results in Tables 7 and 8 the peak hour (8.15am-9.14am) total flow is 34% of the three hour flow. ATC data suggests that, for the M40 junction, the flow between 8.00am and 8.59am was 35% of the flow between 8.00am and 10.59am.

3.19 There are two possible reasons for this apparent difference. Firstly the peak hour time periods are not the same; there is a 15 minute difference. Secondly the three hour flow in Table 8 is for slightly longer than three hours, representing the duration of filming.

3.20 All the above analysis is based on location to location trip matrices. These are actually derived from camera to camera information. This is analysised in more detail in Appendix E. Individual camera matching rates are generally consistent with overall performance.

3.21 An additional feature of the REGNUMS matching process is that it enables a trip time distribution to be established. Although recorded to the nearest minute, these times are considered to be reasonably accurate, since all camera recording times were synchronised at the start of the survey. The three hour trip time distributions for full and partial numberplates are shown in Table 9. The similarity between these

distributions underlines the confidence in the partial numberplate matching process.

3.22 It is concluded that the overall accuracy of the results is very satisfactory giving a reliable analysis of traffic movements. It is worth noting that, whilst the numberplate recognition system processed video tapes in real time, accurate manual processing of a sample part of a tape was found to take six times longer than real time.

3.23 This combined with a well planned survey and a smooth interface between the numberplate recognition system and matching software resulted in a time scale of less than 2 months between survey and production of final report.

4. CONCLUSIONS

4.01 This survey had two objectives:

- to provide data for the current study into widening the M25 between the M40 and M4
- to demonstrate that the technique of computer image processing produces accurate and reliable results.

4.02 The data described in this report gives a clear understanding of how this section of the M25 is used for straight through and turning trip movements. A simple analysis has been made of the data. More refined analysis is possible using the video tapes and computer data files.

4.03 The fact that these data have been collected and analysed is evidence that the technique of computer image processing produces accurate and reliable results. This statement is qualified in the light of the weather and traffic conditions which prevailed on the day of the survey. Nonetheless, there is every reason to expect that the technique would perform well under more severe conditions.

4.04 Valuable lessons were learnt in the operation of such surveys which were put to subsequent and immediate use for more major surveys on the M1, A1(M) and M25. In a very short period of time, what would until very recently have been considered near impossible data collection and analysis tasks have become feasible and cost effective using this technique. Furthermore, the speedy production of results without compromising quality suggests that the technique will fulfil a valuable role in the field of transportation planning.

TABLE 1 SUMMARY OF DATA BY CAMERA POSITION

Camera No.	Location	Lane	Junction	File Name	Start Time	Finish Time	No of Plate Triggers	No of Plates	Manual Count
1	M40 e/b → M25 s/b	(Near)	J16	ANEARSID °ALL	08.05	11.09	1324	1016	1080
2	M40 e/b → M25 s/b	(Off)	J16	AOFFSIDE °ALL	08.05	11.08	1549	1457	1649
3	M25 s/b	(Near)	J16	BNEARSID °ALL	08.06	11.09	3033	2055	2460
4	M25 s/b	(Centre)	J16	BCENTRE °ALL	08.07	11.11	4133	3195	3646
5	M25 s/b	(Off)	J16	BOFFSIDE °ALL	08.10	11.12	4558	3301	3864
6	M40 w/b → M25 s/b	(Near)	J16	CNEARSID °ALL	08.05	11.06	2322	2156	2337
	SUB TOTAL				–	–	16919	13180	15036
7	M25 s/b	(Near)	J15	DNEARSID °ALL	08.13	11.15	1716	1486	1699
8	M25 s/b	(Centre)	J15	DCENTRE °ALL	08.13	11.16	3258	3070	3329
9	M25 s/b	(Off)	J15	DOFFSIDE °ALL	08.14	11.17	4405	4141	4401
10	M25 s/b → M4 e/b	(Near)	J15	EEASTNSD °ALL	08.14	11.16	2797	2592	2669
11	M25 s/b → M4 e/b	(Off)	J15	EEASTOFF °ALL	08.14	11.13	586	491	580
12	M25 s/b → M4 w/b	(Near)	J15	EWESTNSD °ALL	08.13	11.16	1672	1455	1521
13	M25 s/b → M4 w/b	(Off)	J15	EWESTOFF °ALL	08.13	11.16	1114	1064	1180
	SUB TOTAL				–	–	15548	14299	15349

TABLE 2 RELATIONSHIP BETWEEN MANUAL COUNT, PLATE TRIGGERS AND THE NUMBER OF RECOGNISED PLATES

Camera No	(M)ain or (S)lip	Lane	MANUAL COUNT Cars	Others	Total	% Cars	No of Plates Total Flow %	Plate Triggers Total Flow %
1	S	Near	796	284	1080	74	94	123
2	S	Off	1580	69	1649	96	88	94
3	M	Near	1130	1330	2460	46	84	123
4	M	Centre	2699	947	3646	74	88	113
5	M	Off	3726	138	3864	96	85	118
6	S	Near	1876	461	2337	80	92	99
	SUB TOTAL		11807	3329	15036	79	88	113
7	M	Near	587	1112	1699	35	88	101
8	M	Centre	2497	832	3329	75	92	98
9	M	Off	4250	151	4401	97	94	100
10	S	Near	2169	500	2669	81	97	105
11	S	Off	558	22	580	96	85	101
12	S	Near	807	714	1521	53	96	110
13	S	Off	1096	84	1180	93	90	94
	SUB TOTAL		11964	3415	15379	78	93	101

TABLE 3 THREE HOUR MATCHED MOVEMENTS BETWEEN ENTRY AND EXIT POINTS (FULL NUMBERPLATES)

	TO JUNCTION 15 M4 w/b	M25 s/b	M4 e/b	Total Matched	Total Observed	Matching Rate
FROM JUNCTION 16						
M40 eastbound	20(0.3)	910(13.4)	426(6.2)	1356(19.9)	2729	50%
M25 southbound	954(14.0)	2514(36.9)	795(11.7)	4263(62.6)	9970	43%
M40 westbound	194(2.8)	880(12.9)	122(1.8)	1196(17.5)	2337	51%
Total matched	1168(17.1)	4304(63.2)	1343(19.7)	6815(100.0)	15036	45%
Total observed	2701	9429	3249	15379		
Matching rate	43%	46%	41%	44%		45%

Note: Figures in brackets represent percentages of total matched.

TABLE 4 EFFECT ON THE THREE HOUR MATCHING RATE OF USING PARTIAL NUMBERPLATES

	Matched Numberplates	Matching Rate
Full Numberplate (5/5, 6/6, 7/7 chars)	6815	45%
Full Numberplate plus 6/7 chars (2288)	9103	60%
Full Numberplate plus 5/7, 5/6 chars (1064)	10167	67%

TABLE 5 THREE HOUR MATCHED MOVEMENTS BETWEEN ENTRY AND EXIT POINTS (PARTIAL NUMBERPLATES)

	TO JUNCTION 15 M4 w/b	M25 s/b	M4 e/b	Total Matched	Total Observed	Matching Rate
FROM JUNCTION 16						
M40 eastbound	10(0.3)	368(11.0)	166(4.9)	544(16.2)	2729	20%
M25 southbound	448(13.4)	1383(41.2)	468(14.0)	2299(68.6)	9970	23%
M40 westbound	70(2.1)	384(11.5)	55(1.6)	509(15.2)	2337	22%
Total matched	528(15.8)	2135(63.7)	689(20.5)	3352(100.0)	15036	22%
Total observed	2701	9429	3249	15379	-	-
Matching rate	20%	23%	21%	22%	-	22%

Note: Figure in brackets represent percentages of total matched.

TABLE 6 THREE HOUR MATCHED MOVEMENTS BETWEEN ENTRY AND EXIT POINTS (FULL AND PARTIAL NUMBERPLATES)

	TO JUNCTION 15 M4 w/b	M25 s/b	M4 e/b	Total Matched	Total Observed	Matching Rate
FROM JUNCTION 16						
M40 eastbound	30(0.3)	1278(12.6)	592(5.8)	1900(18.7)	2729	70%
M25 southbound	1402(13.8)	3897(38.3)	1263(12.4)	6562(64.5)	9970	66%
M40 westbound	264(2.6)	1264(12.4)	177(1.8)	1705(16.8)	2337	73%
Total matched	1696(16.7)	6439(63.3)	2032(20.0)	10167(100.0)	15036	68%
Total observed	2701	9242	3249	15379	-	-
Matching rate	63%	70%	63%	66%	-	67%

Note: Figure in brackets represent percentages of total matched.

TABLE 7 GROSSED UP AM PEAK HOUR MATCHED MOVEMENTS BETWEEN ENTRY AND EXIT POINTS (FULL AND PARTIAL NUMBERPLATES)

	TO JUNCTION 15			
	M4 w/b	M25 s/b	M4 e/b	Total
FROM JUNCTION 16				
M40 eastbound	13(0.3)	624(12.1)	333(6.5)	970(18.9)
M25 southbound	667(13.0)	1836(35.8)	646(12.6)	3149(61.4)
M40 westbound	146(2.8)	737(14.4)	130(2.5)	1013(19.7)
Total	826(16.1)	3197(62.3)	1109(21.6)	5132(100)

Note: Figures in brackets represent percentage of total flow

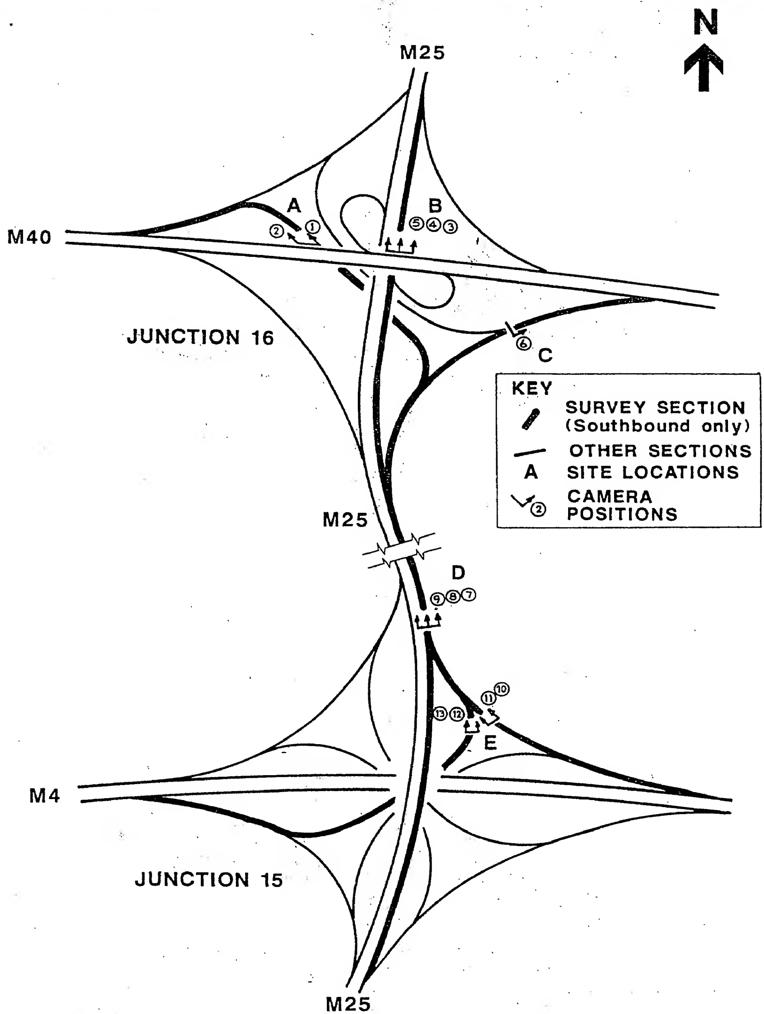
TABLE 8 GROSSED UP 3 HOUR MATCHED MOVEMENTS BETWEEN ENTRY AND EXIT POINTS (FULL AND PARTIAL NUMBERPLATES)

	TO JUNCTION 15			
	M4 w/b	M25 s/b	M4 e/b	Total
FROM JUNCTION 16				
M40 eastbound	45(0.3)	1853(12.2)	898(5.9)	2796(18.4)
M25 southbound	2183(14.4)	5789(38.1)	1969(13.0)	9941(65.5)
M40 westbound	390(2.6)	1794(11.8)	264(1.7)	2448(16.1)
Total	2618(17.3)	9436(62.1)	3131(20.6)	15185(100)

Note: Figures in brackets represent percentage of total flow

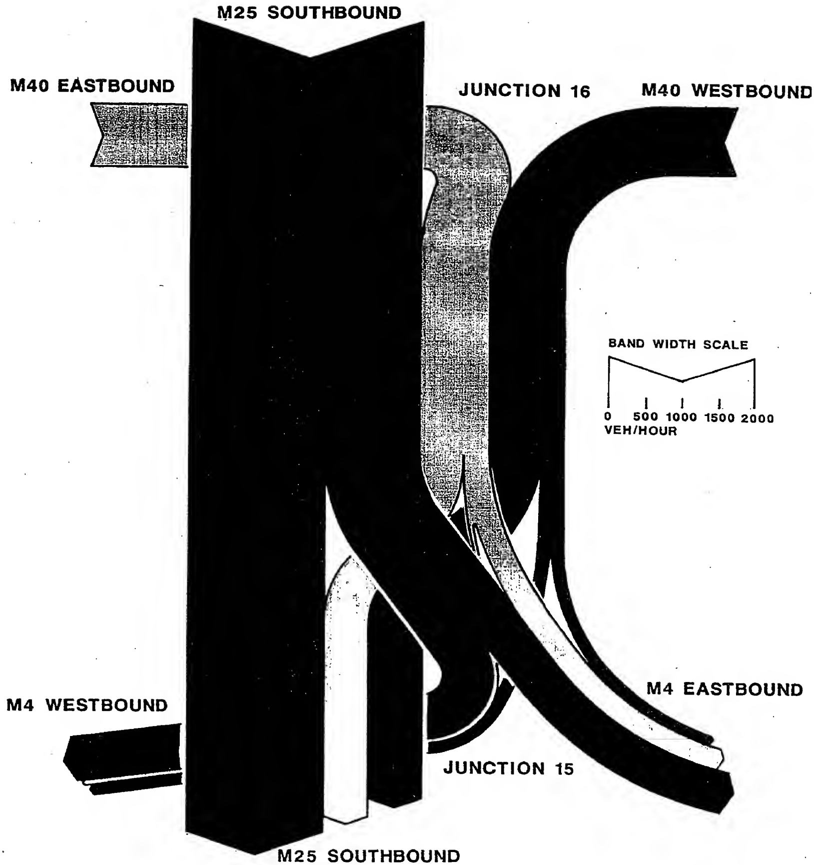
TABLE 9: THREE HOUR TRIP TIME DISTRIBUTIONS BETWEEN JUNCTIONS 16 AND 15 (SOUTHBOUND)

Trip Time (Minutes)	Full Numberplates	Partial Numberplates
Less than 3	6	23
3	35	22
4	235	144
5	431	214
6	463	208
7	422	183
8	524	254
9	951	420
10	1430	643
11	1151	604
12	716	383
13	303	153
14	115	77
15	16	24
More than 15	17	0
	6815	3352



AREA COVERED BY SURVEY

FIGURE 1



GROSSED UP AM PEAK HOUR MATCHED MOVEMENTS (FULL AND PARTIAL NUMBER PLATES)

FIGURE 2

APPENDIX A

FORMAT OF COMPUTER DATA FILES

APPENDIX A FORMAT OF COMPUTER DATA FILES

There is ONE observation per line.
The format of data records is:-

cc	1 - 7	Registration Number (left justified)
cc	8	Blank
cc	9 - 12	Time of observation (right justified)
cc	13	Blank
cc	14	Vehicle Type (Default value, 1)
cc	15	Blank
cc	16 - 17	Camera Number
cc	18	Blank
cc	19	E or L - Entering or Leaving the cordon

NEXT LINE

Registration Number and Entering/Leaving code are letters and numerics. All other values are numeric only.

APPENDIX B

ACCEPTABLE NUMBERPLATE SYNTAXES

APPENDIX B ACCEPTABLE NUMBERPLATE SYNTAXES

The computer image processing technique is a three stage process. Firstly the numberplate is identified. Secondly the numberplate is digitized and then finally it is fitted to an acceptable numberplate syntax. In order to maximise recognition rate, only a limited number of syntaxes are used by the processing technique, representing the majority of modern vehicles. These are:

L NNN	LLL	LLL	NNNL
L NN	LLL	LLL	NNL
L N	LLL	LLL	NL

(Where L = letter and N = number).

Vehicles registered before 1962 and those with personalised, military or foreign numberplates, whilst legal, will not be recognised by the technique. However, numberplates which are identified and digitised but which cannot be fitted to an acceptable syntax are written to disk. From disk they can be manually keyed into the data file irrespective of syntax.

APPENDIX C

SUMMARY OF AUTOMATIC AND MANUAL TRAFFIC COUNTS

MANUAL CLASSIFIED COUNTS FROM VIDEO TAPES ARE SUMMARISED BELOW:

M40 EASTBOUND TO M25 SOUTHBOUND

¼ Hour Beginning	CAMERA 1			CAMERA 2			BOTH		
	Cars	Others	Total	Cars	Others	Total	Cars	Others	Total
0800*	75	9	84	204	3	207	279	12	291
0815	97	24	121	164	8	172	261	32	293
0830	76	15	91	158	4	162	234	19	253
0845	71	30	101	134	2	136	205	32	237
0900	53	25	78	113	8	121	166	33	199
0915	48	14	62	120	5	125	168	19	187
0930	72	20	92	117	6	123	189	26	215
0945	62	24	86	118	3	121	180	27	207
1000	42	24	66	104	7	111	146	31	177
1015	68	26	94	110	8	118	178	34	212
1030	53	25	78	96	12	108	149	37	186
1045	52	28	80	94	1	95	146	29	175
1100*	27	20	47	48	2	50	75	22	97
TOTAL	796	284	1080	1580	69	1649	2376	353	2729

* Incomplete time period

M25 SOUTHBOUND AT JUNCTION 16

¼ Hour Beginning	CAMERA 3			CAMERA 4			CAMERA 5			TOTAL		
	Cars	Others	Total	Cars	Others	Total	Cars	Others	Total	Cars	Others	Total
0800*	89	45	134	99	25	124	59	1	60	247	71	318
0815	188	90	278	248	54	302	289	13	302	725	157	882
0830	140	81	221	154	59	213	255	4	259	549	144	693
0845	126	93	219	198	64	262	288	7	295	612	164	776
0900	122	121	243	231	75	306	277	19	296	630	215	845
0915	101	119	220	258	92	350	338	8	346	697	219	916
0930	100	114	214	233	72	305	326	6	332	659	192	851
0945	63	131	194	238	106	344	363	13	376	664	250	914
1000	56	132	188	209	90	299	311	18	329	576	240	816
1015	38	121	159	218	91	309	366	20	386	622	232	854
1030	28	92	120	206	66	272	306	10	316	540	168	708
1045	33	100	133	228	76	304	289	11	300	550	187	737
1100*	46	91	137	179	77	256	259	8	267	484	176	660
TOTAL	1130	1330	2460	2699	947	3646	3726	138	3864	7555	2415	9970

* Incomplete time period

M40 WESTBOUND TO M25 SOUTHBOUND

¼ Hour Beginning	CAMERA 6		
	Cars	Others	Total
0800*	149	13	162
0815	211	24	235
0830	269	38	307
0845	204	40	244
0900	172	48	220
0915	116	41	157
0930	131	43	174
0945	123	27	150
1000	124	40	164
1015	109	43	152
1030	104	37	141
1045	86	41	127
1100*	78	26	104
Total	1876	461	2337

* Incomplete time period

M25 SOUTHBOUND AT JUNCTION 15

¼ Hour Beginning	CAMERA 7			CAMERA 8			CAMERA 9			TOTAL		
	Cars	Others	Total	Cars	Others	Total	Cars	Others	Total	Cars	Others	Total
0800*	3	5	8	18	6	24	-	-	-	21	11	32
0815	49	64	113	228	44	272	421	9	430	698	117	815
0830	56	62	118	228	63	291	392	9	401	676	134	810
0845	42	73	115	230	55	285	422	6	428	694	134	828
0900	56	94	150	177	77	254	379	15	394	612	186	798
0915	38	96	134	210	51	261	357	15	372	605	162	767
0930	61	88	149	189	67	256	372	7	379	622	162	784
0945	39	97	136	204	75	279	367	24	391	610	196	806
1000	34	106	140	182	87	269	384	19	403	600	212	812
1015	44	115	159	179	82	261	355	21	376	578	218	796
1030	40	96	136	203	64	267	268	8	276	511	168	679
1045	58	101	159	206	90	296	284	8	292	548	199	747
1100	54	98	152	218	68	286	217	9	226	489	175	664
1115*	13	17	30	25	3	28	32	1	33	70	21	91
TOTAL	587	1112	1699	2497	832	3329	4250	151	4401	7334	2095	9429

* Incomplete time period

M25 SOUTHBOUND TO M4 EASTBOUND

¼ Hour Beginning	CAMERA 10			CAMERA 11			TOTAL		
	Cars	Others	Total	Cars	Others	Total	Cars	Others	Total
0815	211	28	239	82	1	83	293	29	322
0830	204	30	234	54	1	55	258	31	289
0845	205	24	229	59	3	62	264	27	291
0900	171	29	200	72	3	75	243	32	275
0915	186	35	221	45	3	48	231	38	269
0930	185	42	227	50	2	52	235	44	279
0945	188	49	237	39	1	40	227	50	277
1000	170	60	230	47	2	49	217	62	279
1015	186	63	249	39	1	40	225	64	289
1030	144	38	182	23	2	25	167	40	207
1045	137	48	185	24	1	25	161	49	210
1100	170	49	219	24	2	26	194	51	245
1115	12	5	17	-	-	-	12	5	17
TOTAL	2169	500	2669	558	22	580	2727	522	3249

M25 SOUTHBOUND TO M4 WESTBOUND

¼ Hour Beginning	CAMERA 12			CAMERA 13			TOTAL		
	Cars	Others	Total	Cars	Others	Total	Cars	Others	Total
0800*	6	5	11	8	0	8	14	5	19
0815	46	47	93	80	1	81	126	48	174
0830	67	34	101	84	6	90	151	40	191
0845	56	55	111	94	6	100	150	61	211
0900	64	50	114	81	5	86	145	55	200
0915	61	73	134	99	5	104	160	78	238
0930	76	57	133	78	2	80	154	59	213
0945	82	57	139	87	6	93	169	63	232
1000	73	65	138	106	15	121	179	80	259
1015	66	82	148	87	10	97	153	92	245
1030	73	70	143	68	6	74	141	76	217
1045	68	59	127	149	16	165	217	75	292
1100	66	53	119	68	6	74	134	59	193
1115*	3	7	10	7	0	7	10	7	17
TOTAL	807	714	1521	1096	84	1180	1903	798	2701

* Incomplete time period

COMPARISON BETWEEN AUTOMATIC AND MANUAL TRAFFIC COUNTS ON 30/10/90

	8am - 9am		9am - 10 am		10am - 11 am		Total	
	ATC	Man	ATC	Man	ATC	Man	ATC	Man
<u>JUNCTION 16</u>								
M40 E/b → M25 S/b	1320	1285*	838	808	791	750	2949	2834*
M25 S/b (including M40 slips)	5473	5434*	5172	5035	4836	4449	15481	14918*
M40 W/b → M25 S/b	1069	1056*	696	701	581	584	2346	2341*
<u>JUNCTION 15</u>								
M25 S/b → M4 E/b	1287	1202*	1154	1100	1092	985	3533	3287*
M25 S/b	3420	3271*	3186	3155	3104	3034	9710	9460*
M25 S/b → M4 W/b	746	768*	900	883	1035	1013	2681	2664*

* Factored time period

APPENDIX D

PROCEDURE FOR DERIVING GROSSED UP TRAFFIC MOVEMENTS

APPENDIX D PROCEDURE FOR DERIVING GROSSED UP TRAFFIC MOVEMENTS

The in-house REGNUMS software ultimately produces a computer file containing details of numberplates matched between entering and leaving points (by camera position). For each camera position it is therefore possible to determine a matching rate as follows:

$$\text{Matching rate for each camera} = \frac{\text{total numberplates matched}}{\text{total vehicles observed}}$$

For each traffic movement cell in the overall trip matrix, there is one matching rate associated with the entering camera position and one associated with the leaving camera position. The grossing up factor for each trip (as represented by a matched numberplate) is as follows:

$$\text{Grossing up factor} = \frac{1}{\sqrt{\text{matching rate entering} \times \text{matching rate leaving}}}$$

e.g. matching rate entering = 70%
matching rate leaving = 80%

$$\text{Grossing up factor} = \frac{1}{\sqrt{0.7 \times 0.8}}$$

$$= 1.\ 4$$

Once matching rates have been determined for each camera position for the time period in question, REGNUMS will calculate grossing up factors for individual movements. No account is taken in this procedure of recognition rates, which are indicative of camera performance only.

APPENDIX E

CAMERA TO CAMERA TRIP MATRICES

APPENDIX E CAMERA TO CAMERA TRIP MATRICES

The following is an analysis of the production of Tables 3 and 6

THREE HOUR MATCHED MOVEMENTS BETWEEN CAMERAS (INPUT TO TABLE 3) (FULL NUMBERLATES)

		TO JUNCTION 15							Total Matched	Total Observed	Matching Rate
		M4 w/b		M25 s/b			M4 e/b				
		12	13	7	8	9	10	11			
FROM JUNCTION 16											
M40 e/b	1	8	0	103	163	107	165	15	561	1080	52%
	2	6	6	34	160	343	196	50	795	1649	48%
M25 s/b	3	169	56	233	122	127	161	29	897	2460	36%
	4	230	126	157	514	218	276	30	1551	3646	43%
	5	127	246	10	173	960	255	44	1815	3864	47%
M40 w/b	6	94	100	148	324	408	96	26	1196	2337	51%
Total matched		634	534	685	1456	2163	1149	194	6815	15036	45%
Total observed		1521	1180	1699	3329	4401	2669	580	15379	-	-
Matching rate		42%	45%	40%	44%	49%	43%	33%	44%	-	45%

Note: See Figure 1 for exact camera locations.

THREE HOUR MATCHED MOVEMENTS BETWEEN CAMERAS (INPUT TO TABLE 6) (FULL AND PARTIAL NUMBERLATES)

		TO JUNCTION 15							Total Matched	Total Observed	Matching Rate
		M4 w/b		M25 s/b			M4 e/b				
		12	13	7	8	9	10	11			
FROM JUNCTION 16											
M40 e/b	1	12	0	141	222	144	227	25	771	1080	71%
	2	7	11	47	240	484	266	74	1129	1649	68%
M25 s/b	3	243	82	352	204	218	273	40	1412	2460	57%
	4	344	189	224	816	338	443	43	2397	3646	66%
	5	182	362	18	273	1454	386	78	2753	3864	71%
M40 w/b	6	134	130	200	473	591	137	40	1705	2337	73%
Total matched		922	774	982	2228	3229	1732	300	10167	15036	68%
Total observed		1521	1180	1699	3329	4401	2669	580	15379	-	-
Matching rate		61%	66%	58%	67%	73%	65%	52%	66%	-	67%

Note: See Figure 1 for exact camera locations.

#2

COPY

Dr A Rawlins
Transport Infrastructure and Operations
Science and Engineering Research Council
Polaris House
North Star Avenue
Swindon SN2 1ET

15 January 1992

Your ref: P:OD:735
Our ref: 1E/SM199/DJR/WMV

Dear Dr Rawlins

T10 LINK APPLICATION T10 48
NETWORK OPTIMISATION USING IMAGE RECOGNITION (NOIR)

We were naturally disappointed that our original proposal to the Transport Infrastructure and Operations LINK Programme was not considered suitable for funding in its present form. We were, however, encouraged by your invitation for us to make a re-submission and this we have prepared. Our re-submission has been further developed to address the comments you make in your letter dated 22 November 1991 and hopefully now represents a project more acceptable to the committee.

On a general point, we agree that our proposal contains a number of separate project areas which could be tackled separately. This was considered by the consortium but in conclusion it was felt that each of the partners, Travers Morgan Consulting Group, Computer Recognition Systems Ltd and Reading University have developed the separate project areas to a point where further work could benefit from a less isolated approach.

The objective of the consortium is to combine the existing experience of the partners towards a common goal and thus integrate and further develop the separate project areas within a single project. In this way we feel that during our research clear definition of the further work to be undertaken within the discrete project areas will be possible.

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Dr A Rawlins
Transport Infrastructure and Operations
Science and Engineering Research Council

15 January 1992

Your ref: P:OD:735
Our ref: 1E/SM199/DJR/WMV

The purpose of improving the existing number plate recognition system represents one of the separate project areas which has implications on the final objectives of other areas. The present number plate reader system (NRS) accuracy is about 70% correct plates during 'reasonable' conditions. This provides an Origination-Destination (O/D) match in the order of 50%. Across a wide range of weather conditions with the NRS current accuracy at 50% O/D matching achievement is about 25%. This is considered not to be sufficient to obtain valid statistics for journey time to undertake automatic control of variable message signs and, therefore, the NRS techniques require improvement. We intend to use classification techniques to augment the NRS accuracy, eg, an attempt at matching strings with a number of character differences. This, we feel, can be more confidently attempted if both vehicles are believed to be of the same class. Therefore numberplate reading and vehicle classification are not disjointed in this project.

The NRS performance improvements will be by algorithm development. We now have a substantial set of recordings from DTp trials we have undertaken and we intend to collect more for the times and conditions not already covered. We intend to investigate the reasons for the reading errors on this data and then develop new algorithms to overcome the appropriate deficiency.

We recognise that it would be impractical to seek recognition of all vehicle number plates at all node points throughout the network and, therefore, we propose to develop a method of sampling. The development of this sampling method and its level of accuracy will be dependent upon identifying a statistical balance between individual number plate capture rates and matching success, and the data requirements of the overall traffic model to achieve acceptable results.

Incumbent upon the above project areas is the role that Reading University will play. They will be developing their previous work in vehicle classification to enhance the NOIR 'system' to include data on vehicle types.

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Dr A Rawlins
Transport Infrastructure and Operations
Science and Engineering Research Council

15 January 1992

Your ref: P:OD:735
Our ref: 1E/SM199/DJR/WMV

We chose Reading University because of their previous and current work in the field and felt this to be more appropriate than any undertaken by Leeds, Newcastle or UCL. More information can be provided to justify our view if required.

Vehicle Recognition has been developed by Reading University using model based methods of 3D vision. These have been shown to work reliably in complex urban road junctions and for ground traffic at airports. The particular merits of the approach are seen as follows:

i) Performance reasonably independent of distance, 3D pose and partial occlusion;
ii) immunity to image noise;
iii) ability to tailor the speciality of the classification to the requirements of the task.

Most existing techniques for visual vehicle classification rely on the ability to outline the image of the vehicle, as a moving region in the image; the attributes of the 2D region are then matched against the values expected of the known classes of vehicle. These methods are highly sensitive to the viewpoint of the camera (wrt the vehicle) and do not cope well with problems due to partial occlusion of vehicles by other vehicles or fixed objects in the field of view.

The methods developed by Reading University, under funding from the UK Alvey Programme (Project MMI-007, 1985-89) and lately from the European Framework Programme (Esprit E2152, VIEWS), uses 3D models to compute the characteristics of the image of a vehicle under any view. The methods have been reported at a succession of British Machine Vision Conferences (1987-91). They are far more robust than the 2D methods since they are less affected by shadows, specular reflections and changes of illumination conditions. They deal naturally with the shape and size changes which occur with changes of viewpoint and are more sensitive to small differences between vehicles.

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Dr A Rawlins
Transport Infrastructure and Operations
Science and Engineering Research Council

15 January 1992

Your ref: P:OD:735
Our ref: 1E/SM199/DJR/WMV

The work proposed under NOIR will be to adapt the algorithms for real-time performance and input the data into the overall system traffic model.

For our submission we chose a project focused on the motorway and trunk road network. This was a deliberate choice because of the strategic benefits of re-routing traffic between primary and secondary routes leading to the ability to optimise road corridors where alternative routes exist. Also a complete communications infrastructure exists on the motorway and much of the trunk road network making the evaluation between central or distributed processing of information a little simpler. We propose that for subsequent system validation a modest motorway corridor be selected which has many of the now standard traffic control and surveillance facilities (CCTV, counting loops, communications infrastructure). This would benefit the validation process and limit the hardware requirements.

We propose that for the validation process we seek collaboration with the Department of Transport, Traffic Control and Communications Division and the appropriate Network Management Division within the Regional Offices. From our experience it would be premature to seek collaboration with these parties at this stage and we feel that the evidence from our project work will provide the vehicle for establishing the final system validation criteria.

During the course of the project some of the discrete project areas will be tested in field trials. Collaboration has already been established between Travers Morgan in association with CRS Ltd and the Department of Transport's Motorway Widening Unit for Origination-Destination surveying on motorways. Trials to evaluate enhanced performance of present techniques will be sought within this collaboration.

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Dr A Rawlins
Transport Infrastructure and Operations
Science and Engineering Research Council

15 January 1992

Your ref: P:OD:735
Our ref: 1E/SM199/DJR/WMV

The work we propose to undertake under the NOIR project, once validated for a motorway environment, could be equally applicable to urban road systems. The concepts are, in the consortium's opinion, most appropriately first explored for a motorway/trunk road network for the reasons outlined previously.

Finally we wish to develop parameters for an expert system to receive, disseminate and react to the information being generated.

We concede that we present to you an ambitious proposal but one that we believe provides realistic goals for the advancement of existing proven technologies towards a clearly defined 'systems' objective. The 'system' would, we suggest, be as powerful a traffic tool as Autoguide and will produce unbiased statistics for all classes of vehicles. It has the benefit of being available to all road users without being reliant upon subscribers.

On behalf of the consortium I hope that these comments, together with our re-submission, are considered suitable for funding under the LINK programme.

Yours faithfully

D J Robertson
for **TRAVERS MORGAN ONE LIMITED**

enc

cc: Mr H Wybourn

LINK

DTp

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TRANSPORT INFRASTRUCTURE AND OPERATIONS PROGRAMME

INITIAL PROJECT PROPOSAL

Before completing this form please read the accompanying General information, Terms and Conditions.

Please type your answers, or write in dark ink using BLOCK LETTERS.

PROJECT TITLE

Please give the full title for the project	Network Optimisation using Image Recognition
Please give acronym for the project	NOIR

APPLICANT DETAILS

Lead Partner	Full name and address of organisation	Travers Morgan One Ltd Mead House Cantelupe Road East Grinstead, West Sussex
	Contact Name	D Robertson Tel: 0342 327161
	Number of employees (SME Only)	
Other Commercial Partners	Name of organisation	Computer Recognition Systems Ltd
	Contact name	W Adaway Tel: 0734 792077
	Number of employees (SME Only)	30
	Name of organisation	
	Contact name	Tel:
	Number of employees (SME Only)	
Science Base Partners	Name of organisation	Reading University
	Contact name	G Sullivan Tel: 0734 318606
	Name of organisation	
	Contact name	Tel:

If you do not have enough space please continue on a separate sheet of paper.

PROJECT DESCRIPTION

Please give a summary of the project, including under separate heading:

brief description of the project;
expected scientific and/or technological advances;
the objectives of the project; and
expected benefits to the UK.

To build upon a method recently developed under a joint venture between Travers Morgan Consulting Group and CRS Ltd, to undertake origination and destination surveys using the latest computerised scanning and recognition techniques. The system developed thus far (FIRST) has been proven in the field for obtaining real-time journey information to identify origination-destination characteristics for a closed network on high speed roads.

The method adopted for the O-D technique is for temporary camera and video equipment to be mounted at all entry and exit points to form a closed network. Video tapes of the traffic flow at each point of the network are provided as the basic data. Each tape is processed by an image recognition system which identifies the number plate of each vehicle and automatically reads and produces a file of the character arrays. Character arrays are matched using a matching programme to determine the entry and exit points from the network for each vehicle and, in so doing, establishes a flow pattern. This survey technique has been used on a number of high speed DTp roads to date with an accepted degree of accuracy.

Our proposal under the LINK programme (NOIR) is to research the feasibility and economic benefits of providing a real-time network optimisation and vehicle classification system based on image processing techniques. The research would focus on existing technologies and, as a first stage, include development work to improve the accuracy of these techniques.

A number of separate project areas exist within the overall project. The work within each of these separate project areas will be complementary to, and dependent upon, the final system parameters. The objectives of the separate project areas are as follows:

i) Enhancement of present number plate reading techniques - CRS Ltd.

ii) Enhancement of present vehicle classification and counting techniques - Reading University.

iii) Establishment of suitable transmission and data collection techniques - Travers Morgan.

If you require further space, please continue on a maximum of two A4 sheets.

PROJECT DESCRIPTION

Please give a summary of the project, including under separate heading:

brief description of the project;
expected scientific and/or technological advances;
the objectives of the project: and
expected benefits to the UK.

iv) Development of a real-time traffic flow model based upon journey time, O-D information and vehicle classification - Travers Morgan.

v) Integrate the information from i) to iv) into a traffic model to optimise the network - all partners.

vi) Investigation of the applicability of expert system techniques to overall system optimisation - all partners.

Close liaison will be necessary by all partners during the development of objectives i) to iv) above. This activity will be co-ordinated by Travers Morgan. The functional requirements of each project area will be constantly assessed and re-defined as necessary to enable the work under objective v) to proceed.

During the development of the project areas, the team propose to seek a method of real-time sampling which will, on a statistical basis, identify journey time and vehicle classification information throughout a network. Analysis will be undertaken on the statistical balance between the number of sampling points/associated hardware and the respective accuracy of successful matching classification data and true representation of traffic patterns.

On a theoretical basis, from the statistical data made available, the team shall undertake the development of a real-time traffic model for strategic routes on a closed network. The purpose of this model will be to analyse, on a real-time basis, the true effects traffic patterns are having on the network. With such a system statistical origination-destination, journey time and vehicle group data will be constantly available. With the benefit of real-time data the team shall seek to quantify the effect and benefit that variable message signs would have as a means of transferring traffic from one route to another. The basic principles of network optimisation will, therefore, be examined together with the proportion of vehicle types using the strategic routes and the split of vehicle types which transfer onto alternative routes.

Utilisation of the existing National Motorway Communications Network for data transmission would be investigated together with the logistics of establishing a

If you require further space, please continue on a maximum of two A4 sheets.

PROJECT DESCRIPTION

Please give a summary of the project, including under separate heading:

brief description of the project;
expected scientific and/or technological advances;
the objectives of the project; and
expected benefits to the UK.

suitable transmission and data collection technique for receiving video information and initiating changes to 'on-site' Variable Message Signs.

The team's work associated with data transmission techniques will be focused on the motorway network where supporting communications infrastructure exists. This will involve collaboration with the Department of Transport, Traffic Control and Communications Division to agree concepts and transmission protocols. Data transmission concepts will be closely co-ordinated with the work associated with enhancing existing technologies to provide the necessary evaluation criteria to decide between the level of central and distributed processing.

Field trials will be undertaken within the scope of this project to evaluate the work undertaken in the separate project areas and its compliance with the objectives developed from the overall system requirements.

The project would culminate with a study into the feasibility of developing an 'expert system' to provide automatic optimisation of the network. In investigating this system we would seek to develop the basis for a software tool which has the characteristics of modifying its behaviour in response to the real-time data collected from sensing outstations. Utilisation of heuristic rules and modification of these in response to future events would be the ultimate aim. The project matter would, therefore, be moving towards a fully automated optimisation system for strategic routes and one which is constantly updated by the data it receives.

'System' validation would be undertaken as a desk study. The consortium's view is that this desk study will indicate the feasibility of the NOIR system and at this stage further government collaboration would be appropriate for further field trials and 'system' validation.

If you require further space, please continue on a maximum of two A4 sheets.

Please describe how and when the research is likely to be applied commercially	Further deveopment work and trials necessary beyond our project to apply techniques commercially.
How long is the project expected to last	18 months
Please state when the project can be started and if there are any limitations as to when the project can be started	As soon as approval is granted
Are you looking for further partners to complete the consortium, if YES please give details	No
Are related projects currently being evaluated under any other publicly funded programmes (including EC programmes), if YES please give details	No
Are you or a member of your consortium already receiving financial support from public funds (including EC funds) for a related project, if YES please give details	Yes. Reading University is currently funded within Esprit, as part of project P2152 VIEWS, to develop methods of recovering descriptions of traffic scenes in complex urban and airport scenes. The work propósed under NOIR will adapt the existing vehicle recognition and classification techniques to the new task.

PROJECT COSTS

Please give estimates of the overall total eligible costs for the project, and indicate for what percentage is Government funding being sought

Industry cost	£ 280	% 77
Science base cost	£ 80	% 23
Total cost	£ 360	% 100

Please give an estimated breakdown, as indicated, for each of the project partners

Organisation	Person Years	Staff Costs	Other Costs
TM One Ltd	2.6	£ 160k	£ 30k
CRS Ltd	1.3	£ 75k	£ 15k
Reading University	1.0	£ 70k	£ 10k
		£	£
		£	£

If you require further space, please continue on separate sheet.

DECLARATION

I declare that the information given on this form is complete and correct.

Signature	Robertson	Date 15 1 92 (dy mth yr)
Name (BLOCK LETTERS)	D. J. ROBERTSON	
Organisation	TRAVERS MORGAN ONG LTD.	
Position in organisation	DIVISIONAL DIRECTOR ELECTRICAL + MECHANICAL DIVISION.	

WHERE TO RETURN YOUR APPLICATION

When completed, please send this form to:-

LINK Transport Infrastructure and Operations Programme Secretariat
Science and Engineering Research Council
Polaris House
North Star Avenue
SWINDON
Wiltshire
SN2 1ET.

TRAVERS MORGAN

Travers Morgan Engineering

Department of Civil Engineering

Mead House
Cantelupe Road
East Grinstead
West Sussex
RH19 3DO

Telephone 0342 327161
Fax 0342 315927

RW Holmes Esq
Head of Signals & Lighting Branch
Traffic Policy Division
Department of Transport
Room 4/30
St Christopher House
Southwark Street
London SE1 OTR

21 February 1992

Our ref: GJH/T/SCS

Dear Sir

Speed Violation Deterrent System at Motorway Widening Sites

Travers Morgan has, as you are no doubt aware, been engaged on trunk road and motorway design and supervision for many years. More recently we have become involved in the Motorway Widening Programme and are currently working on schemes on A1(M), M1 and M20. We have an established working relationship with Computer Recognition Systems Ltd which has to date resulted in development, trial and implementation of "FIRST" (Fast Image Recognition Surveys in Transport). This survey system was specially developed for motorway usage surveys and involves forming a cordon around a section of existing motorway network and recording vehicle movements on to video. The tapes are automatically scanned to identify, read and store registration numbers on to computer files. Subsequent matching provides an entry/exit matrix of vehicle movements from which a detailed pattern of through traffic and junction turning movements is available. This system has been deployed on many live network surveys over the last 18 months.

We are now turning our attention to a second application of image recognition technology which we consider is especially apposite given the forthcoming programme of rapid widening schemes on M25 and elsewhere. The objective will be to provide a driver awareness of permanent speed monitoring within contra-flow systems subject to

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TRAVERS MORGAN

2.
RW Holmes Esq
Traffic Policy Division
Department of Transport
21 February 1992

a statutory 50mph speed limit. Image sensing devices would be positioned on convenient overbridges or sign gantries above contra-flow lane at either end of a speed measurement zone. The image sensors would read number plates and record the detection time at both the first and second monitoring points. Number plates would be matched and the time difference used to calculate the average speed through the pre-measured control zone. The matched data would be transferred to a data stack from which those vehicles complying with the speed limit would be eliminated.

A variable message sign would be located a suitable distance downstream of the control zone to which the number plate and measured speed would be transmitted for display with a legend as set out below:

H 1 2 3 A B C
MEASURED SPEED
63 MPH

Signface to be located in close proximity to 50mph repeater signs

The legend would be set up to be viewed by the errant vehicle driver and held for say 5 seconds. When the time comes to change the legend the next appropriate matched pair from the data stack would be transmitted. At times of heavy flow there would be detected speed violators which would not be able to be displayed as they pass "within the shadow" of a displayed vehicle. Nevertheless all drivers would be aware that surveillance was in constant operation and that individual offenders are identifiable.

We believe that this application would provide a powerful deterrent to speed violation and bring about a positive improvement in safety to both road users and contractors operatives.

We very much welcome your agreement to a desk top demonstration at St Christopher House at 2pm on Thursday 2 April 1992. We understand you will invite representatives from

Motorway Widening Unit
Regional Offices
Highway Engineering Design
Transport Road Research Laboratories
Network & General Maintenance Division

.../3

#3

TRAVERS MORGAN

We suggest a presentation time of 30 minutes to be followed by questions and discussion for whatever period you consider appropriate.

It would be appreciated if you could advise us in advance of the names and positions of those attending the presentation. We would also wish to access the presentation room one hour ahead of the meeting time. Should you have any queries please do not hesitate to contact the writer.

Yours faithfully

G J Hill
for TRAVERS MORGAN ENGINEERING

TRAVERS
MORGAN

GJH/T/SC

#4

Speed Violation Deterrent System at Motorway Widening Sites Suggested Format for Desk-Top Demonstration at St Christopher House, Southwark Street, London SE1 0TE at 2pm Thursday 2 April 1992

Attending: R W Holmes - Head of Signs, Signals and Lighting Branch, Traffic Policy Division

Representatives from:

Motorway Widening Unit
DTp Regional Offices
Highway Engineering Division
Network General and Maintenance Division
TRRL

G J Hill - Travers Morgan
D Robertson - Travers Morgan

- CRS

General Presentation Content

1. Introductions

2. Short demonstration of image recognition of number plates.

3. Outline of speed violation deterrent system based on actual M20 site conditions.

4. Simulated system demonstration using M20 site video data.

5. Proposed site installation system.

6. Questions and discussions - likely topics:-

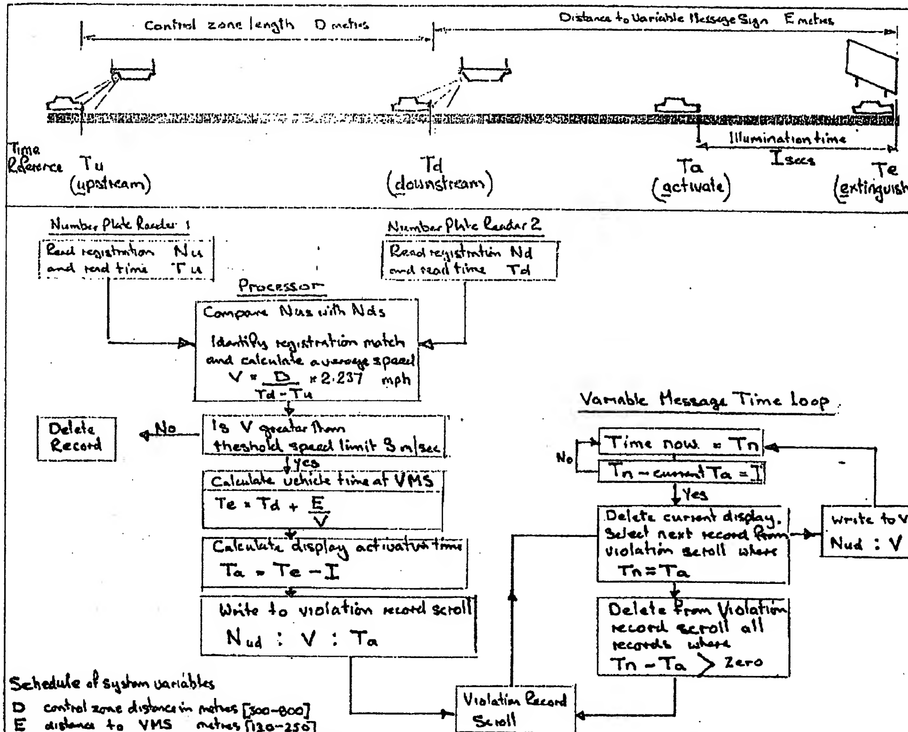
   i) site trial;
   ii) operating limitations (weather and daylight);
   iii) maintenance;
   iv) data transmission mode and vulnerability;
   v) operating cost;
   vi) system accuracy and calibration method;
   vii) variable message sign type, size and location;
   viii) legal aspects and approvals procedures.

Detailed Demonstration Content
(TM suggestions for discussion with CRS)

			Action By
Item 2:	Short demonstration of image recognition of number plates		
	2-3 minute video sequence of monitors showing traffic lane recording, registration number identification and numbers being read from the selected image rectangles (all as used in FIRST survey demonstrations).		CRS
Item 3:	a)	Diagram 1 showing basic system, ie. image sensors mounted on overbridges or gantries at measured distance apart. Data transmission to processing box. Output to variable message sign.	TM
	b)	Diagram 2 showing processing logic flow chart.	TM
	c)	Diagram 3 showing layout of simulation trial from M20.	TM
	d)	Short video sequence of the M20 site showing the contraflow conditions and the image sensor locations.	TM
Item 4:	Simulated Demonstration (using time-synchronised video recording from M20)		
	a)	Monitors showing the two recorded traffic flows identified as upstream (A) and downstream (B).	CRS
	b)	Allow time to demonstrate vehicles passing A, subsequently appear at B.	CRS
	c)	Engage NRS to show registration numbers being identified with recorded time at positions A and B.	CRS
	d)	Engage matching speed calculations and message generation software showing scrolling stack of violation records being produced.	CRS
	e)	Output to a monitor screen simulating the variable message sign, displaying registration number and measured speed. Screen holds each legend for say 5 seconds and is then replaced by the registration number of the violating vehicle calculated to be approaching the VMS. If stack is empty VMS goes blank.	CRS

TRAVERS MORGAN

Project						
Made by	Date	Checked by	Date	Issued by	Date	Job number/Sheet number
				GHill 21-2-00		



Schedule of system variables

D control zone distance in metres [300-800]
E distance to VMS metres [130-250]
V Violation speed threshold miles/hour [75 mph - 30 mph]
I Illumination time secs [3-7]

SPEED VIOLATION DETERRENT SYSTEM

GWD/130

TRAVERS MORGAN

Travers Morgan Consulting C

#5

From: G J Hill

To: M Springett, R Wilson, G Davies
D Robertson, W Adaway (CRS)

Copies:

Job no:
File ref: GJH/T/SCT
Date: 3 April 1992

Internal Notes Telecon
Memo / Meeting / Telecon / File Note (Type in above)

Job:

Subject: Speed Violation Detection at Major Roadworks

Telecon: Superintendent Piet Biesheuvel, Police Liaison Officer, Transport and Road Research Laboratory, Crowthorne, Berkshire RG11, 6AU (Tel: 0344 770221)/GJH, 3 April 1992

1. Superintendent Biesheuvel phoned having been present at the presentation at St Christopher House on 2 April.

2. He is the Police Liaison Officer at TRRL, coordinating activity between Association of Chief Police Officers ACPO and TRRL.

3. SB requested 15 copies of the presentation document to allow it to be circulated to the Speed Enforcement Technology Group which is one of four special sub-committees of ACPO. They meet next on 13 May. GJH undertook to provide copies of relevant sections of the document since Supt. Biesheuvel undertook that the Committee would submit their views on the system in writing to TM/CRS. He anticipates they will be fully supportive of the concept and of progressing to a trial.

4. He emphasised that the Police would regard the DTp as the funding agency for major roadworks applications but the Speed Enforcement Technology Group would endorse any method they consider would assist in achieving better speed limit compliance. The Police are only interested in portable installations for prosecution purposes and that such equipment must receive Home Office Type Approval in conjunction with the Police Scientific Development Branch.

5. Supt. Biesheuvel shares my impression from the presentation that although it stimulated much interest it was difficult to identify where the initiative to progress to a site trial would come from.

6. A useful contact with positively supportive views.

GJH.

ROOM 3/21
ST CHRISTOPHER HOUSE
SOUTHWARK STREET LONDON SE1 0TE
TELEX 21352
FAX 071-921 4410
DIRECT LINE 071-921
SWITCHBOARD 071-928 3666
GTN 3813
FAX 071 921 4569

#6

THE DEPARTMENT OF TRANSPORT

1E 860L/Com

Mr G Hill
Travers Morgan
Mead House
Cantelupe Road
EAST GRINSTEAD
West Sussex

Your Ref:

Our Ref:

Date: 20 January 1993

Dear Mr Hill

File 1E/4/14.

Trial of Speed Violation Detection/Deterrent System

I am pleased to tell you that you have approval to trial your system subject to agreeing the siting and other practical details with SE CPD. The fixed and variable message traffic signs will need to meet the requirements of the Traffic Signs Regulations and General Directions 1981.

Yours sincerely

R W HOLMES
Network Management Driver Information Division

SWH/T/SCT
20 JAN 1993
SWH
KJ
DR
CRS Fax
NBI Fax

File 1E/4/14

TRAVERS MORGAN
Consultants in Engineering, Management, Transport and the Environment

Travers Morgan Engineering

Department of Civil Engineering

Mead House
Cantelupe Road
East Grinstead
West Sussex
RH19 3DG

Telephone 0342 327161
Fax 0342 315927

Chief Inspector J Dinner
Assistant Secretary
ACPO Standing Sub-Committee on
Road Traffic Enforcement Technology
Devon and Cornwall Constabulary
Middlemoor
EXETER EX2 7HQ

7 September 1993

Our ref: GJH/T/SCT

Dear John

Speed Violation Detection/Deterrent Trial

We have just completed the fourth week of the SVDD operation in the full deterrent mode. I thought it would be worthwhile updating you on the trend in driver behaviour prior to the Sub-Committee meeting this month. The tables below summarise the weekday and weekend driver behavioural response.

Weekday Violations

	Date		24 matched flow	Mean Speed mph	% Violations
Covert monitoring	Fri 16 April 1993		4804	51.3	46.4%
Deterrent mode	Fri 20 August	day 14	4241	46.8	17.0%
	Fri 27 August	day 21	6498	46.7	15.8%
	Fri 3 September	day 28	6164	46.7	15.8%

Weekend Violations

	Date		24 matched flow	Mean Speed mph	% Violations
Covert monitoring	Sun 11 April		4476	54.1	64.3%
Deterrent mode	Sun 22 August	day 16	4572	47.8	25.6%
	Sun 29 August	day 23	5889	47.7	26.8%
	Sun 5 September	day 30	6468	47.5	24.0%

cont'd/2...

Chief Inspector J Dinner
ACPO Standing Sub-Committee on
Road Traffic Enforcement Technology

Our ref: GJH/T/SCT

7 September 1993

There are several trends to be noted:-

i) As the deterrent effect develops, there are more drivers using lane 1.

ii) The deterrent effect for weekday motorists shows signs of levelling out, having reduced the proportion of violating motorists to about one-third of the covert monitoring level. The 85% speed is now at the 50mph statutory limit and the numbers of high speed violations are less then one-quarter of the covert monitoring level.

iii) The deterrent effect is slower to develop at weekend with (we assume) greater numbers of motorists experiencing the system for the first time. The 85% speed is at 53mph and the proportion of daily violators is approaching one-third of the covert monitoring data level.

We are somewhat encouraged by the degree of reduction in speed violations achieved to date, especially as there is no current direct link to prosecution.

Since we last met, it is evident that the Department of Transport is very interested to know more about the requirement of ACPO in progressing SVDD into a fully authorised prosecution system, especially in the context of the 'Controlled Motorways' pilot scheme proposed for M25. We would therefore wish to be advised of the position as soon as the Sub-Committee reaches a conclusion.

Yours sincerely

G J Hill
for TRAVERS MORGAN ENGINEERING

cc Spt. Good - Essex
Spt. Spearman - Kent

#7